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(54) INJECTION-MOLDED THERMOPLASTIC SATURATED NORBORNENE RESIN, SUBSTRATE OF INFORMATION MEDIUM ELEMENT MADE THEREFROM, AND INFORMATION MEDIUM ELEMENT.

(57) An injection-molded article which is made from a thermoplastic saturated norbornene resin having a number-average molecular weight of 10,000 to 80,000 in terms of a standard polystyrene as determined by gel permeation chromatography using toluene as the solvent and which has a thin-wall part with a width of 20 mm or above and a thickness of 700 μm or less along the direction of flow from the gate. The above resin provides a thin-wall molding with a given shape, a given quality and a thickness of 700 μm or less. When the thin-wall part is a sheet, it is also possible to obtain a sheet which is reduced in an unevenness of the thickness. Further it is possible to obtain a molding excellent in surface smoothness by using a well polished mold.

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TECHNICAL FIELD

This invention relates to an injection-molded thermoplastic saturated norbornene type resin article, an information medium element substrate using said resin article, and an information medium element, and more particularly to an injection molded article made of a thermoplastic saturated norbornene type resin which has a thin-gaged part having a thickness of 700 μm or less and extending to a span of 25 mm or above along the flow line from the gate, an information medium element substrate using said resin article and an information medium element.

TECHNICAL BACKGROUND

In information recording elements such as photo memory card substrate and the like and information medium elements such as information displaying elements including liquid crystal display and the like, the incident light and reflected light must be constantly refracted and reflected without irregular reflection, in order to assure the reliability of information input and output by light. For this purpose, the surface of information medium element is required to be flat and smooth and uniform in thickness.

As such information medium element substrate, glass plates having a ground surface have been used. Glass plates, however, have a fault that they are brittle, readily breakable and weighty. Thus, transparent thermoplastics are sometimes used in place of glass.

For forming a thermoplastic material into a thin-gage molded article having a thickness of 700 μm or less and a sufficient area, melt-extrusion processes such as T-die process, inflation process and the like or calender roll process, hot press process and the like are adopted. Although injection molding process has a merit that it easily gives a product of constant shape and constant quality, injection molding process is inferior in flow characteristics. That is, at a position farther than 20 mm from the injection molding gate along the flow line, the resin is not readily flowable, so that a thin-gage article having a sufficient spread is difficult to obtain so far as thickness of the article is 700 μm or less. Thus, with the aim of obtaining a thin-gage article having a thickness of 700 μm or less and a sufficient spread, a variety of attempts such as (1) lowering the molecular weight of resin, (2) elevating the temperature of resin, (3) enhancing the pressure of injection, (4) enhancing the speed of injection, etc. have been made.

Now, as transparent resin for optical use, polymethyl methacrylate resin (hereinafter referred to as PMMA) and polycarbonate resin (hereinafter referred to as PC) are mainly used. If the molecular weight of resin is lowered or the resin temperature is elevated or the pressure or speed of injection is enhanced with the aim of injection-molding these PMMA and PC resins into an article having a thickness of 700 μm or less and a sufficient spread, there arise various problems such as decrease in the strength of molded article due to deterioration caused by shearing heat, appearance of turbidity in molded article, coloration of molded article, etc. At the present time, accordingly, thin-gage articles made of a transparent optical resin are not manufactured by injection molding process actually. Furthermore, PMMA has a fault that it is inferior in water-absorbing property and heat resistance, and PC has a fault that it is insufficient in water-absorbing property and high in birefringence.

In the recent years, thermoplastic saturated norbornene type resins are watched with interest as a material suitable for production of an optically uniform sheet, because its moisture absorption is 0.05% or below and usually 0.01% or below, demonstrating its excellence in moisture resistance, and its photoelastic constant is as small as $3 - 9 \times 10^{-13}$ cm^2/dyne. Regarding such thermoplastic saturated norbornene type resins, too, thin-gage injection-molded product having a thickness of 700 μm or less and a sufficient spread is yet unknown, though it is known that sheets or thin-gage molded products of constant thickness can be produced from these resins by melt-extrusion process, calendering process, hot press process and the like.

In an information recording element substrate, the irregularity in thickness of the sheet must be at most ±30 μm and preferably at most ±15 μm as measured on the whole area. In an information displaying element substrate, an irregularity in thickness of such an extent can cause distortion of image, and therefore the irregularity in thickness in such a sheet must not exceed at most ±10 μm, preferably at most ±5 μm and further preferably at most ±2 μm as measured on the whole area. In an information recording element substrate, fine grooves smaller than 1 μm are usually formed for the purpose of deciding the position of information record and making the input and output of information exact. In such an element, important are not only exactness of the shape of grooves but also smoothness of the groove-free flat part and superficial part. In the groove-free part and superficial part, the surface roughness must be at most 0.1 μm, preferably at most 0.07 μm and further preferably at most 0.03 μm as expressed in terms of maximum height Rmax.

When a thermoplastic saturated norbornene type resin is formed into a sheet by T die method, inflation method, calender roll method or the like, it is difficult to simultaneously satisfy the both con-

ditions mentioned above concerning uniformity of thickness and smoothness of surface. Even though the above-mentioned conditions may be satisfied when the resin is formed by the solution casting method, this method has a problem that efficiency of production is not good, the solvent is apt to remain to lower the strength, and the remaining solvent slowly vaporizes to make the dimension unstable.

Further, the solution casting method has been unable to produce a sheet having a groove-form structure like in information recording element substrates.

DISCLOSURE OF INVENTION

The object of this invention consists in providing a transparent resin molded article for optical use excellent in water resistance, moisture resistance and transparency, low in birefringence, excellent in surface smoothness, small in irregularity of thickness and sufficient in strength and dimensional stability which has a thin-gage part having a thickness of 700 µm or less and extending to a span of 25 mm or above along the flow line from the gate.

The present inventors have conducted extensive studies with the aim of solving the above-mentioned problems of prior art. As a result, it has been found that a thermoplastic saturated norbornene type resin is excellent in flow characteristics and therefore the resin is excellent in the injection-moldability into a thin-gage article and the above-mentioned object can be achieved by injection-molding the resin.

BEST EMBODIMENT FOR PRACTICING THE INVENTION

(Thermoplastic Saturated Norbornene Type Resin)

As the thermoplastic saturated norbornene type resin used in this invention, those disclosed in Japanese Patent Application KOKAI Nos. 3-14882, 3-122137 and 4-63807 can be referred to. Concretely, hydrogenated products of ring-opened polymers of norbornene type monomers, addition polymers of norbornene type monomers, addition copolymers of a norbornene type monomer and an α-olefin and the like can be referred to. As the norbornene type monomer, mixtures of two or more kinds of norbornene type monomers are also usable. The methods of polymerization and hydrogenation are not particularly limited, but conventional methods may be adopted.

As the norbornene type monomer, the known monomers disclosed in the patent gazettes of the above-mentioned Japanese Patent Application KOKAI Publications or in the patent gazettes of Japanese Patent Application KOKAI Nos. 2-227424 and 2-276842 can be referred to. Concretely speaking, norbornene; alkyl-, alkylidene- and aromatic substituted derivatives thereof, and compounds prepared by substituting these substituted or unsubstituted olefins with a polar group such as halogen, hydroxyl group, ester group, alkoxy group, cyano group, amido group, imido group, silyl group and the like can be referred to. Examples of such norbornene type monomer include 2-norbornene, 5-methyl-2-norbornene, 5,5-dimethyl-2-norbornene,5-ethyl-2-norbornene, 5-butyl-2-norbornene, 5-ethylidene-2-norbornene, 5-methoxycarbonyl-2-norbornene, 5-cyano-2-norbornene, 5-methyl-5-methoxycarbonyl-2-norbornene, 5-phenyl-2-norbornene, 5-phenyl-5-methyl-2-norbornene, 5-hexyl-2-norbornene, 5-octyl-2-norbornene, 5-octadecyl-2-norbornene and the like; monomers prepared by adding one or more cyclopentadiene units to norbornene; derivatives or substituted products of these compounds which have been derived or substituted in the same manner as above such as 1,4:5,8-dimethano-1,2,3,4,4a,5,8,8a-2,3-cyclopentadienonaphthalene, 6-methyl-1,4:5,8-dimethano-1,4,4a,5,6,7,8,8a-octahydronaphthalene, 1,4:5,10;6,9-trimethano-1,4,4a,5,6,7,8,8a-octahydronaphthalene, 1,4;5,10;6,9-trimethano-1,2,3,4,4a,5,5a,6,9,9a,10,10a-dodecahydro-2,3-dihydrodicyclopentadienoanthracene and the like; polycyclic monomers which are polymers of cyclopentadiene and derivatives or substituted products thereof which have been derived or substituted in the same manner as above such as dicyclopentadiene (hereinafter referred to as DCP), 2,3-dihydrodicyclo-pentadiene and the like; adducts of cyclopentadiene and tetrahydroindene and the like and derivatives or substituted products thereof which have been derived or substituted in the same manner as above such as 1,4-methano-1,4,4a,4b,5,8,8a,9a-octahydrofluorene, 5,8-methano-1,2,3,4,4a,5,8,8a-octahydro-2,3-cyclopentadienonaphthalene, 4,9:5,8-dimethano-3a,4,4a,5,8,8a,9,9a-octahydro-1H-benzindene (hereinafter referred to as PCDE) and the like; etc.

In this invention, at the time of subjecting a norbornene type monomer to ring-opening polymerization according to known method, other ring-opening-polymerizable cycloolefins may be used in combination therewith so far as the effect of this invention is not obstructed by the combined use. As the concrete examples of such cycloolefin, compounds having one reactive double bond such as cyclopentene, cyclooctene, 5,6-dihydrodicyclopentadiene and the like can be referred to.

Number average molecular weight of the thermoplastic saturated norbornene type resin used in

this invention is 10,000 to 80,000 and preferably 15,000 to 60,000, as measured by GPC (gel permeation chromatography) method using a toluene solvent and converted to by using standard polystyrene. If the number average molecular weight is too low, the molded article is inferior in mechanical strength. If the number average molecular weight is too high, the resin is not good in flow characteristics and injection molding of the resin requires elevation of resin temperature, etc., and a molded article having a desired wall thickness is difficult to obtain.

In hydrogenating a ring-opened polymer of a norbornene type monomer, the degree of hydrogenation should be 90% or above, preferably 95% or above, and further preferably 99% or above, from the viewpoint of thermal deterioration resistance, light deterioration resistance, etc.

Glass transition temperature (Tg) which is an index indicating the heat resistance of a resin is measured by DSC (differential scanning calorimetry) method. Tg is preferably 100 °C or above, and further preferably 120 °C or above. A higher Tg means a higher heat resistance of molded article, which is more desirable. However, if Tg is too high, resin temperature must be elevated at the time of injection molding in order to improving the flow characteristics. Accordingly, preferable Tg is 180 °C or below. Usually, molecular weight has an important meaning as a determining factor for Tg of resin. In the above-mentioned range of molecular weight, however, molecular weight exercises only a small influence on Tg, and kind of monomer has a more important meaning as a determining factor for Tg. Preferably, kind of monomer should be selected appropriately in the case of homopolymers and copolymerization ratio between the used monomers should be selected appropriately in the case of copolymers, so as to give an appropriate Tg. For example, in the case of hydrogenated product of norbornene type ring-opened homopolymer, preferable monomers generally include polycyclic monomers having 4 or more cyclic units such as 1,4:5,8-dimethano-1,2,3,4,4a,5,8,8a-2,3-cyclopentadienonaphthalene, 6-methyl-1,4:5,8-dimethano-1,4,4a,5,6,7,8,8a-octahydronaphthalene and the like. In this case, Tg of the hydrogenated product of thermoplastic norbornene type ring-opened polymer is usually about 130 °C or above. Generally speaking, Tg of hydrogenated product of norbornene type ring-opened homopolymer becomes higher as the number of cyclic units in monomer increases. Further, Tg of hydrogenated product of norbornene type ring-opened homopolymer is greatly influenced by the kind and number of substituents on the fundamental structure of the polycyclic compound used as a monomer. Care must be taken so that Tg does not reach too high a value.

Similarly, in the case of hydrogenated product of norbornene type ring-opened copolymer, Tg is influenced by the number of cyclic units in the monomer used, the kind of substituent, the composition ratio, etc. As preferable examples of the combination of monomers, combinations of two or more kinds of norbornene type monomers including a polycyclic monomer having 4 or more cyclic units, for example, a combination of a bicyclic monomer such as 2-norbornene, 5-ethyl-2-norbornene or the like or/and a tricyclic monomer such as dicyclopentadiene, 2,3-dihydrodicyclopentadiene or the like and a polycyclic monomer having 4 or more cyclic units, a combination of a plurality of polycyclic monomers having 4 or more cyclic units, etc. can be referred to. In the case of hydrogenated products of ring-opened copolymers constituted of about 50-5% by mole of a recurring unit derived from PCDE and a residual quantity of a recurring unit derived from DCP, Tgs are in the range of from a little lower than 180 °C to about 110 °C, respectively.

(Additives or Agents to Be Mixed)

If desired, additives such as an anti-aging agent (phenolic compounds, phosphorus compounds and the like), a thermal deterioration preventer such as phenolic compounds and the like, an ultraviolet stabilizer such as benzophenone compounds and the like, an antistatic agent such as amine compounds and the like, a lubricant such as esters of aliphatic alcohols, partial esters or partial ethers of aliphatic alcohols and the like, etc. may be added to the thermoplastic saturated norbornene type resin used in this invention.

Further, other transparent resin may be mixed into the thermoplastic saturated norbornene type polymer of this invention, so far as the object of this invention is not affected. As the transparent resin, PMMA, PC, polystyrene resin and the like can be referred to. To molded articles requiring no transparency, a variety of fillers may be added for the purpose of improving strength, etc.

(Injection Molding)

For obtaining the molded article of this invention, a usual injection molding machine of which clamping pressure is about 40 tons or above can be used. As injection pressure and injection speed, conventional conditions for the injection molding machine to be used may be adopted, while injection molding temperature should be decided with consideration of flow characteristics of the polymer. Usually, the molding is carried out at 280-360 °C, and preferably at a relatively high resin tempera-

ture of 290-350 °C. If the resin temperature is too low, flow characteristics are not good, so that a molded article is difficult to obtain. If the resin temperature is too high, thermal deterioration takes place to cause various problems such as reduction in the strength of molded article, coloration of molded article, etc.

Usually, injection of resin is carried out at a die temperature of from 70 °C to Tg + 10 °C, preferably from 90 °C to Tg + 5 °C. If the die temperature at the time of injection is too low, the injected resin is rapidly cooled in the die and its solidification is promoted, so that flow characteristics of resin are deteriorated. Depending on the structure of the die, the resin cannot be fully filled into corners of the die, and the intended molded product is difficult to obtain. If the die temperature is too high, the die must be allowed to cool sufficiently after completion of injection in order to solidify the resin, which usually leads to a decrease in production efficiency. When molding is carried out at a die temperature falling in a range of from Tg-20 °C to Tg + 10 °C and particularly from Tg-10 °C to Tg + 10 °C, it is generally preferable to sufficiently lower the die temperature after completion of injection. For sufficiently lowering the die temperature, a means of presetting a long die-cooling period after completion of injection, etc. may be adopted. When the die temperature after completion of injection is higher than Tg, it is also allowable to preset the die temperature so as to change in accordance with a molding cycle. As above, the die temperature at the time of injection should be decided with consideration of flow characteristics of resin on the basis of die structure, resin temperature, Tg of resin, necessary cooling period of die, production efficiency, etc.

Generally speaking, after completion of injection, solidification of the resin starts from the peripheral zone. Thus, the resin solidifies while undergoing a stress from the firstly solidified peripheral zone to the inner zone. As its result, a residual stress appears, due to which birefringence increases. In the molded article of this invention, contrariwise, the whole of thin-gage part having a thickness of 700 μm or less solidifies nearly at once without substantial difference between the peripheral zone and inner zone, so that a great residual stress does not appear readily. Further, even if there appears a great residual stress, birefringence of a thermoplastic saturated norbornene type resin cannot readily take a great value, because magnitude of birefringence is dependent on the product of residual stress and photoelastic constant and thermoplastic saturated norbornene type resins have a small photoelastic constant.

The surface of the die used for injection molding must be smooth as a whole. If the surface of die is not smooth, no molded article having a smooth surface can be obtained. If necessary, grooves are formed on one side of the die. When grooves are formed, it is necessary that the areas other than the grooves have no irregularities of 1 μm or greater at all. For this purpose, the surface of die must be made as smooth as possible previously. As the techniques for processing a die and a stamper, the prior processing techniques of dies for information recording disks can directly be adopted.

(Injection Molded Article)

The molded article of this invention has a thin-gage part having a prescribed thickness and extending to a span of 25 mm or above, preferably 30 mm or above, and further preferably 40 mm or above along the flow line from the gate. However, if a molded article of this invention has an area of excessively small thickness, the area is low in strength. Further, an article having an excessively thin area is difficult to produce by injection molding because the gap of dies must be too small. Accordingly, it is desired that the thickness in the thinnest area is usually at least 100 μm and preferably at least about 200 μm.

The sheet which is a molded article of this invention can be used as an information recording element substrate or an information displaying medium element substrate. In the case of information recording element substrate, the irregularity in thickness of the sheet must be ±30 μm or less, preferably ±15 μm or less, on the whole surface. In the case of information displaying element substrate, an irregularity of such an extent is enough to cause distortion of image. Therefore, when a particularly precise image is required, the irregularity in thickness of the sheet must be ±10 μm or less, preferably ±5 μm or less, and further preferably ±2 μm or less on the whole surface. In an information recording element, minute grooves for deciding the position of information record having a size of smaller than 1 μm, called "grooves", are usually formed. In an information displaying element, reflection must be prevented. For these reasons, smoothness of surface is also important, and the maximum height (Rmax) must be 0.1 μm or less, preferably 0.07 μm or less, and further preferably 0.03 μm or less. When the sheet is used as an information displaying medium element substrate, too, the situation is similar to the above. These injection molded articles required to have a high surface precision can be obtained by sufficiently grinding the surface of die used in the injection molding process. Dies which have been ground and thereafter made to have a further surface smoothness by means of chromium plating or the

like are particularly preferred.

In the injection-molded article of this invention, the birefringence is small in the thin-gage part having a thickness of 700 μm or less. Usually, the greatest value of birefringence throughout the whole surface is 40 nm or less, preferably 30 nm or less, and particularly preferably 20 nm. For making small the birefringence as possible, it is recommendable to select a combination of die temperature and resin temperature so as to minimize the residual stress, depending on the shape of die, etc.

Since the injection-molded article of this invention is made of a thermoplastic saturated norbornene type resin excellent in transparency, an article having a light transmittance of 90% or above can easily be obtained. For enhancing the light transmittance, it is recommendable to use an impurity-free thermoplastic saturated norbornene type resin while taking watchful care to eliminate fine flaws of the surface causing irregular reflection, and at the same time to decrease the maximum height Rmax, namely an index of surface roughness. For this purpose, it is recommendable to use a die which has been ground and chromium-plated in the above-mentioned manner.

Since the injection-molded article of this invention is made of a thermoplastic saturated norbornene type resin low in moisture absorbing property, its saturated moisture absorption after standing in water at 25 °C for 24 hours is usually 0.1% or less, preferably 0.05% or less, and particularly preferably 0.01% or less.

The injection-molded article of this invention is excellent in heat resistance and shows no noticeable change in color tone and no heat distortion even if heated at 100 °C. Further, since the injection molding process of this invention uses no solvent unlike solution casting process, the quantity of solvent remaining in the molded article is as small as usually 0.1% or less, preferably 0.05% or less and further preferably 0.01% or less. Thus, it hardly undergoes distortion due to vaporization of solvent even if used in a high-temperature atmosphere, and it exercises substantially no adverse influence on the environments due to the vaporized solvent.

Since the molded article of this invention is formed by the injection molding process, it is possible to make one molded article involve a structure for bonding to other parts or a structure of other different function in addition to the thin-gage part. In the parts other than the thin-gage part, the thickness may exceed 700 μm.

The sheet of this invention can be used as an information recording element substrate in which grooves are formed on a circular sheet having a size of 80-90 mmΦ or 120-130 mmΦ, or as an information displaying medium element substrate which is a rectangular or square sheet having a diagonal length of about 1-10 inches.

(Information Recording Element)

In using the molded article of this invention as an information recording element substrate, an information recording layer must be provided on the grooved surface. As the information recording layer, the following can be referred to: known rare earth-transition metal amorphous alloys such as Tb-Fe type, Dy-Fe type, Cd-Tb-Fe type, Cd-Tb-Dy-Fe type, Cd-Co type, Tb-Fe-Co type and the like; a variety of known phase change type recording layers such as Ge-Te type, Sb-Te type, In-Sb type, Gb-Sb-Te type, In-Sb-Te type and the like; known organic dye type recording layers such as methine-polymethine type, quinones (naphthoquinone, anthraquinone and the like), phthalocyanines, dithiols, tetrahydrocholines, dioxanes, dithiazines, porphyrins and the like; known write-once type recording layers such as Te-CS_2 type, Pb-Te-Se type, Te-C type, TeO_2 type, Sb-Se type, Bi-Te type and the like and postscript type recording layers using the shape change caused by bubble formation; metallic light reflecting layers such as Au, Pt, Al and the like; and light reflecting layers capable of reflecting only particular wavelengths in which SiO_2, metal oxide, metal fluoride and the like are laminated to a specified thickness to form a multilayer structure.

(Liquid Crystal Substrate)

The molded article of this invention can be used as an information displaying medium element substrate such as liquid crystal substrate and the like. Of the two sheets of liquid crystal substrates used as constructing parts of a liquid crystal display, at least one must be laminated with a transparent electrode layer. The transparent electrode layer must have at least a certain magnitude of light transmittance to visible light. The light transmittance is usually 50% or more and preferably 70% or more; and specific resistance is usually 100 Ωcm or less and preferably 50 Ωcm or less. Concretely, thin film of metals such as Au, Ag, Cu, Pt, Al, Cr, Pd and the like, thin film of semiconductors and oxide semi-conductors such as In_2O_3(Sn), SnO_2(Sb), SnO_2(Fe), CdO, Cd_2O_3, $CdSnO_4$, TiO_2, ZrO_2, CuI and the like, multi-layer thin films such as TiO_x/Ag/TiO_x ($x \leq 2$) and the like, poly-electrolyte thin film systems such as polyvinylbenzyl-trimethylammonium chloride, oligo-(poly)styrenesulfonic acid salt and the like, electrically conductive polymers such as polyanilines, polythiophenes, polypyrroles and the like, etc. can

be referred to. These conductive films are laminated on a liquid crystal substrate according to a known method such as spraying method, plasma method, gas phase reaction system (CVD), coating method (CLD), vacuum vapor deposition method, RF or DC sputtering method, ion plating method, electrolytic polymerization method or the like. It is also possible to give the thin film an electroconductivity by impregnating the film with a complex compound such as TTF-TCNQ (tetrathio-fulvalene/tetracyanoxydimethane) or the like.

[Working Example]

Hereinunder, this invention is explained more concretely by referring to referential example, examples and comparative example.

(Example 1)

To 100 parts by weight of a polymer (number average molecular weight 28,000, hydrogenation rate approximately 100%, glass transition temperature 152°C) obtained by hydrogenating a ring-opened polymer of 6-methyl-1,4:5,8-dimethano-1,4,4a,5,6,7,8,8a-octahydronaphthalene (MTD) was added 0.2 part by weight of pentaerythrityl-tetrakis-(3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate) as a phenolic anti-aging agent, and the resulting mixture was pelletized by the method of melt extrusion.

The pellets were injection-molded under the following conditions to obtain a thin-gage molded article.

Die:
90 mm x 55 mm x 500 μm thickness x two-impression; with a surface ground and smoothly finished by chromium plating; with a slit-form gate having a size of 90 mm x 500 μm from which resin is injected perpendicularly.
Molding machine:
Clamping pressure 85 tons.
Resin temperature:
325°C.
Die temperature:
110°C (fixed side), 100°C (movable side).

The molded product thus obtained was subjected to various tests to obtain the results mentioned below.

Appearance:
The molded product had a size of 90 mm x 55 mm x 500 μm. This size was just equal to that of the die.
Warpage:
The molded product was placed on a flat plate, and the warpage was visually examined by the use of Newton ring. The warpage was at most 50 μm.
Irregularity in thickness:
The irregularity did not exceed ±1 μm over the whole area of the sheet, except for the peripheral zone of 5 mm width.
Minute unevenness:
Measured with a surface roughness-meter. The result was 25 nm or less as expressed in the term of Rmax.
Transparency:
The color tone was transparent visually, and the light transmittance was 90% or above in the whole visible light region.
Birefringence:
Measured by double paths at a wavelength of 633 nm. The birefringence was at most 20 nm over the whole area of sheet.
Residual solvent:
Gas chromatography revealed that the quantities of residual solvents were below the limit of detection (0.01%).
Moisture absorbing property:
After allowing a molded product to stand in water at 25°C for 24 hours, the saturated moisture absorption was determined from the increase in weight. The result was 0.01% or less. The warpage after standing for 24 hours was 50 μm or less, and no great moisture-absorbing distortion was noticeable.
Heat resistance:
After heating a molded product in air oven at 100°C, no change was noticeable in color tone. The warpage was still 50 μm or less, and no great heat distortion was noticeable.

(Example 2)

The same anti-aging agent as in Example 1 was added to 100 parts by weight of a hydrogenated product (number average molecular weight 27,000, rate of hydrogenation approximately 100%, glass transition temperature 133°C) of a copolymer obtained by ring-opening polymerization of a MTD/dicyclopenta-diene (DCPD) mixture (MTD/DCPD = 70/30 by mole), and the resulting mixture was pelletized.

The pellet was injection-molded under the following conditions to obtain the results mentioned below.

Die:
90 mmΦ x 350 μm thickness x one-impression; equipped on its surface with a stamper partially grooved in the same manner as those used in the information recording disks; the size of the groove was 600 nm (width) x 85 nm (depth).
Molding machine:
Clamping pressure 65 tons.
Resin temperature:
335°C.

Die temperature:

110 °C (fixed side), 100 °C (movable side).

The molded product thus obtained was subjected to various tests to obtain the results mentioned below.

Appearance:

The molded product had a size of 90 mmΦ × 350 μm thickness. This size was just equal to that of the die.

Warpage:

The molded product was placed on a flat plate, and the warpage was visually examined by the use of Newton ring. The warpage was at most 50 μm.

Irregularity in thickness:

The irregularity did not exceed ±1 μm over the whole area of the sheet, except for the peripheral zone of 5 mm width.

Minute unevenness:

Measured with a surface roughness-meter. The result was 20 nm or less as expressed in the term of Rmax.

Transparency:

The color tone was transparent visually, and the light transmittance was 90% or above in the whole visible light region.

Birefringence:

Measured by double paths at a wavelength of 633 nm. The birefringence was at most 20 nm over the whole area of sheet.

Residual solvent:

Gas chromatography revealed that the quantities of residual solvents were below the limit of detection (0.01%).

Moisture absorbing property:

After allowing a molded product to stand in water at 25 °C for 24 hours, the saturated moisture absorption was determined from the increase in weight. The result was 0.01% or less. The warpage was 50 μm or less, and no great moisture-absorbing distortion was noticeable.

Heat resistance:

After heating a molded product in air oven at 100 °C, no change was noticeable in color tone. The warpage was still 50 μm or less, and no great heat distortion was noticeable.

Groove transferability:

The formed grooves had a depth of 78 nm or above.

(Comparative Example 1)

After preliminarily drying PC (manufactured by Teijin Kasei, trade name AD5503) in an air oven at 120 °C for 4 hours, its injection molding was attempted in the same manner as in Example 1. However, the molded product did not take the intended shape, but the resin could be filled only to a distance of about 10 mm from the gate.

Next, the resin temperature was elevated to 350 °C, and molding was attempted at an enhanced injection speed. However, the resin was decomposed by the shearing heat and a white-colored molded product was obtained.

The molded article of this invention is constituted of a thermoplastic saturated norbornene type resin. By injection molding said resin, a molded article which has a thin-gage part having a thickness of 700 μm or less and extending to a span of 25 mm along the flow line from the gate can be easily obtained with a constant shape and constant quality. Accordingly, this invention is superior in molding efficiency. Further, when the thin-gage part is a sheet, a sheet small in the irregularity of thickness can be obtained. Further, by using a sufficiently ground die, a molded article excellent in surface smoothness can be obtained.

Further, the molded article of this invention is free from the distortion due to vaporization of the solvent remaining in the resin and from the adverse influence on the environments. The molded article of this invention is excellent in moisture resistance and heat resistance. In addition, in the molded article of this invention, the thin-gage part is low in birefringence and high in transparency.

INDUSTRIAL UTILIZABILITY

By using a thermoplastic norbornene type resin excellent in optical characteristics and moisture resistance, a molded article of, for example, sheet-form, having a thickness of 700 μm or below can be obtained by the injection molding process. The molded article thus obtained can be used in various fields, and its industrial utilizability is very high.

Claims

1. An injection-molded article constituted of a thermoplastic saturated norbornene type resin having a standard polystyrene-converted number average molecular weight of from 10,000 to 80,000 as measured by gel permeation chromatography using a toluene solvent, said article having a thin-gage part which extends to a span of 25 mm or above along the flow line from the gate and has a thickness of 700 μm or less.

2. An information medium element substrate made of the injection-molded article according to Claim 1.

3. An information medium element using the information medium element substrate according

to Claim 2.

4. An information medium element substrate according to Claim 2, which is an information recording element substrate.

5. An information medium element substrate according to Claim 2, which is an information displaying element substrate.

6. An information medium element according to Claim 3, which is an information recording element.

7. An information recording element according to Claim 6, which is an optical disk.

8. An information recording element according to Claim 6, which is a photo memory card.

9. An information displaying element according to Claim 3, which is an information displaying element.

10. An information displaying element according to Claim 9, which is a liquid crystal display.

INTERNATIONAL SEARCH REPORT

International Application No PCT/JP92/01027

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl[5]. B29C45/00, C08F32/08, C08L45/00

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	B29C45/00, C08F32/08, C08L45/00

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho 1950 - 1991
Kokai Jitsuyo Shinan Koho 1971 - 1991

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	JP, A, 61-188444 (Nippon Zeon Co., Ltd.), August 22, 1986 (22. 08. 86), (Family: none)	1-10
A	JP, A, 62-181323 (The B. F. Goodrich Co.), August 8, 1987 (08. 08. 87), (Family: none)	1-10
A	JP, A, 2-29308 (Nippon Zeon Co., Ltd.), January 31, 1990 (31. 01. 90), (Family: none)	1-10

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
October 16, 1992 (16. 10. 92)	November 2, 1992 (02. 11. 92)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	

Form PCT/ISA/210 (second sheet) (January 1985)